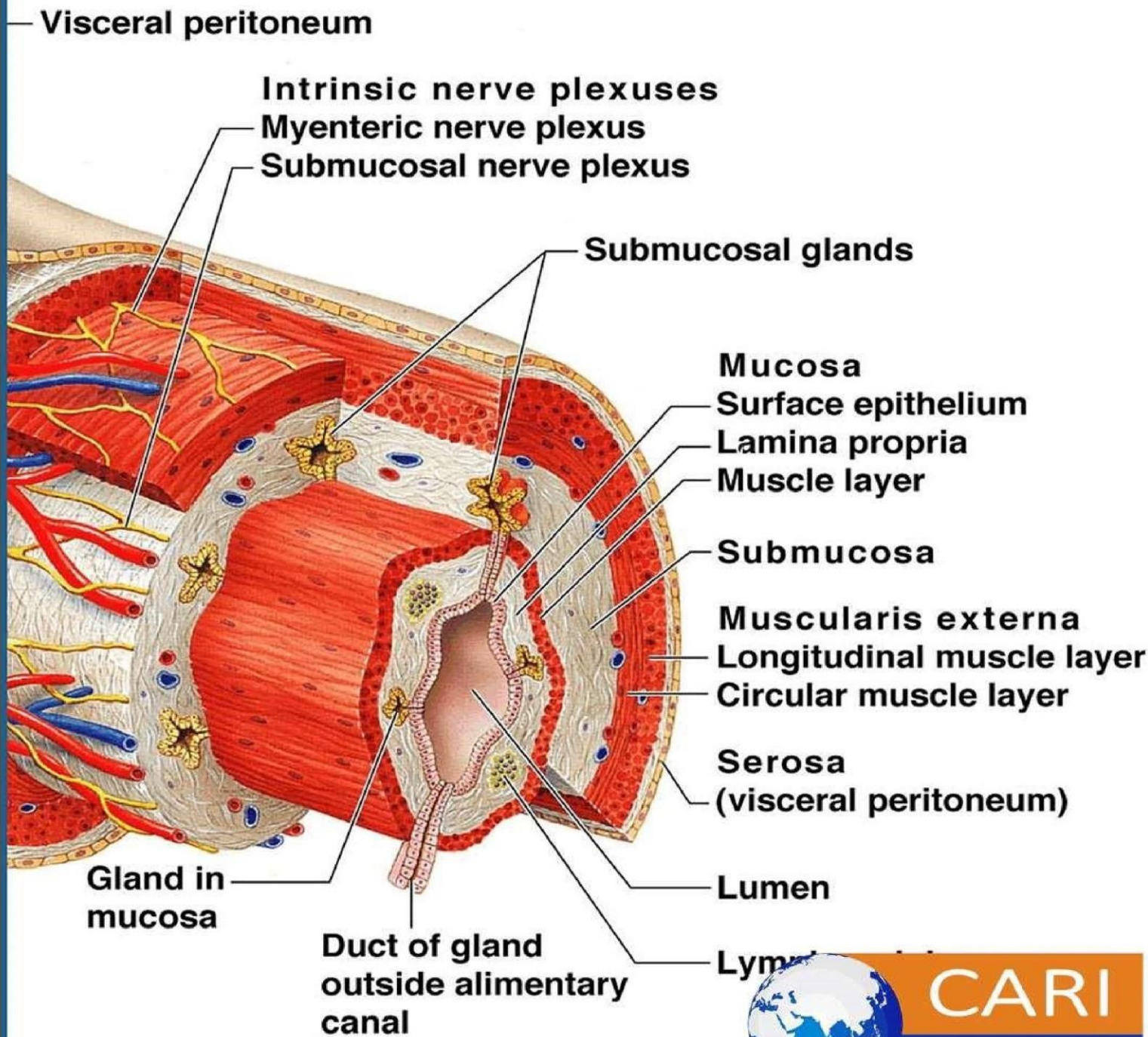


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EFFECT OF VIRUS AND MYCOPLASMA DISEASES ON THE PRODUCTIVITY OF ALFALFA HAY CULTIVARS

Ibrahim Naser, Emiliano Olbinado and Rodrigo Hermogino



EFFECT OF VIRUS AND MYCOPLASMA DISEASES ON PRODUCTIVITY OF ALFALFA HAY CULTIVARS

¹*Ibrahim Naser

¹Research Dept., TADCO, Tabuk 71421, P O Box 808, Saudi Arabia

*Corresponding Authors E-mail: ibsn2003@hotmail.com.

²Emiliano Olbinado

Research Dept., TADCO, Tabuk 71421, P O Box 808, Saudi Arabia

³Rodrigo Hermogino

Research Dept., TADCO, Tabuk 71421, P O Box 808, Saudi Arabia

Abstract

Purpose: To evaluate the productivity of different alfalfa hay cultivars under the effect of local virus and mycoplasma diseases.

Methodology: The study was conducted under center pivot irrigation system similar to TADCO mechanized alfalfa hay crop production.

Results: Imported alfalfa hay cultivars were found infected with three virus and mycoplasma diseases: alfalfa enation virus, alfalfa mosaic virus and alfalfa witches' broom. Infections with these diseases lead to a severe reduction on the productivity of alfalfa hay cultivars in the third cropping season. Alfalfa enation virus was found to cause the most economic damage to the alfalfa hay crop, and the percentage yield reduction from this disease reached 17.6, 36.8% in the second and third seasons of cultivation respectively.

Unique Contribution to Theory, Practice and Policy: The authors recommended to grow alfalfa hay cultivars with less susceptibility to virus diseases infections as we found variability in the productivity of the tested cultivars. The study also recommends to grow alfalfa hay cultivars under mechanized system for two seasons as we observed significant yield reduction in the third season due to high infestation with weeds and grasses which affected the hay quality. In the first field trial (1999 – 2002), productivity of alfalfa hay cultivars CUF 101 and Siriver reached above 30 M.T./Ha under aphid-controlled conditions. In the second field trial (2002 – 2004), alfalfa hay

productivity of the cultivars Fast Grow, SW 9500, Magic (SW 9301) and Super Supreme reached above 30 M.T./Ha in the first season 2003; and in the second season 2004, productivity of Magic, Fast Grow and Super Supreme reached above 26 M.T./Ha. Productivity over the two seasons 2003 and 2004 shown Fast Grow and Magic were the highest with 60.38, 59.85 M.T./Ha. respectively.

Keywords: *Alfalfa Enation Virus, Alfalfa witches' Broom, Vector Insects, Growing Season, Alfalfa Hay Yield.*

1.0 INTRODUCTION

Alfalfa is an important forage crop for dairy farming companies and domestic animals feeding in some Middle East countries with good source of irrigation water like rivers and in Saudi Arabia in the last decades. It is a useful crop for soil reclamation as it is tolerant to medium soil salinity and improves soil fertility, so it is grown as part of a successful crop rotation with cereal crops besides it is a good source of income to the farmers. This crop is prone to infection by several virus and virus-like diseases in countries with warm weather, affecting its productivity with increasing age of the crop and increasing infection. Recent studies in Saudi Arabia have shown eleven virus diseases were found associated with alfalfa and weeds in the surrounding of the crop fields in five regions of the country (Al-Shahwan et al., 2016). The most common widespread virus diseases were alfalfa enation virus, alfalfa mosaic virus (Calico), and the witches' broom disease caused by mycoplasma (Cook & Wilton, 1984). Alfalfa enation virus is the most important virus disease of alfalfa in Saudi Arabia and in several other countries of the Near East (Marble, 1984). It was found in cultivars trial in Al Kharj that the Egyptian and Saudi local cultivars except Hasawi cultivar had lower infection rate with this disease, while Australian and American cultivars were very susceptible (Cook and Wilton, 1984). The aim of this research work was to evaluate the productivity of different alfalfa cultivars under the local conditions in Tabuk area and under the effect of these diseases to find tolerant cultivars that can be utilized as part of IPM programs in alfalfa hay crop.

Description of the Diseases: (Cook, 1987; Stuteville, and Erwin, 1990).

Alfalfa Enation Virus: Symptoms appears on the Stems with curled and puckered leaflets, and enations on veins on the underside of the leaflets' surfaces. Depressions on the lower side of the leaflets may result from malformation of secondary veins where enations develop, [Figure 1], and the growth rate of infected plants is reduced. The disease is transmitted by cowpea aphid *Aphis cracivora*, it is recognized by the presence of black clusters of aphids on the tops of the alfalfa plants, and it acquires the virus after 2 hours feeding on infected plants followed by incubation period 48 hours inside the insect body then the insect become infected for its whole life (Leclant et al, 1973)

Alfalfa Mosaic (Calico): Virus symptoms vary from minor chlorotic leaf spotting or vein clearing to elongated, necrotic leaf lesions that sometimes coalesce, [Figure 2]. Growth rate of infected plants is slightly affected. This disease is mechanically transmitted to healthy plants once they feed on infected plants by other types of aphids such as blue aphids and pea aphids etc.(Thompson et al, 1985).; also it is a seed-borne disease (Frosheiser, 1969). This disease is transmitted to potato plants growing in pivots adjacent to alfalfa pivots (Calico) by aphids.

Alfalfa witches' Broom: Symptoms of this disease appears as a small chlorotic plant with numerous thin stems typical to infection by witches' broom disease, [Figure 3]. This disease is attributed to mycoplasma organism (Cook and Wilton, 1984). The disease is transmitted by the leafhopper (Jassid) called *Empoasca faba*, the insect acquires the pathogen after few hours feeding on infected plants followed by incubation period one week inside the insect body as it multiplies then the insect become infected for its whole life. Symptoms of more than one virus disease may appear on the plants and in particular alfalfa mosaic disease with alfalfa enation virus or other alfalfa virus diseases (Al-Shahwan, et al 2016).

2.0 MATERIALS & METHODS

Land Preparation: One pivot A04P25 (40 Ha.) was allocated to conduct field crops trials at TADCO over the period 1994 to 2013, soil type was sandy loam, and the water source from a deep well of good quality with EC was below 0.7 mS/cm (< 448 ppm) . For each varietal alfalfa trial, previous crop before alfalfa sowing was wheat or other cereal crops. Pre-irrigation of two rounds of irrigation at a speed of 20% with a total amount of 45 – 50 mm was carried out just after straw bailing, then wait for two weeks to encourage weeds germination then give two passes of irrigation 12 mm followed by cross chisel plow at a depth of 30 cm in the opposite direction (45° angle) and one pass of pipe levelling. Granular fertilizer 14-38-10 was broadcasted at the trial area at a rate of 200 kg/Ha. before sowing the seeds. Alfalfa seeds were treated with Rhizobium inoculum at a rate of 50 gram per one bag of 50 kg seeds.

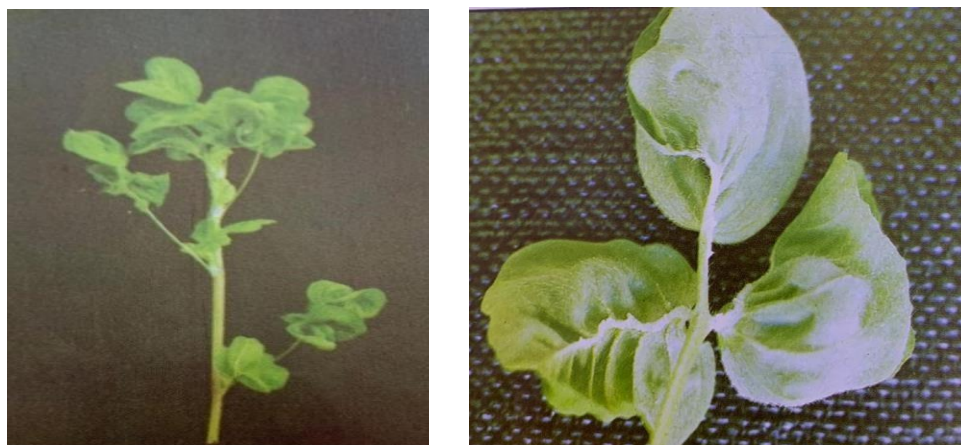


Figure 1. Alfalfa Enation Virus Symptoms (Cook A.A, 1987)



Figure 2. Alfalfa Mosaic Virus Symptoms

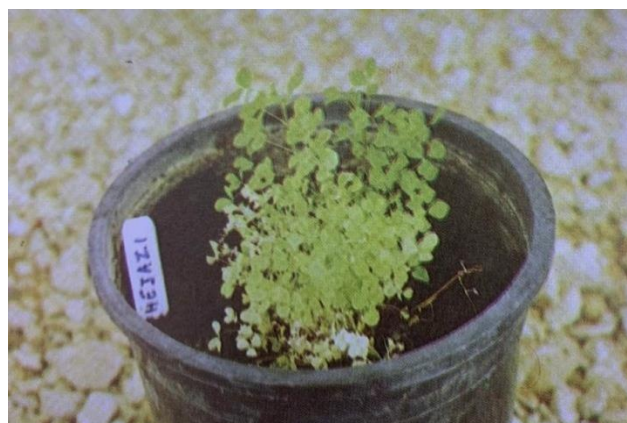


Figure 3. Alfalfa Witches Broom (Cook, 1987)

Trials Layout & Data Recording: Two alfalfa varietal trials were conducted: The first field trial was conducted on October 25, 1999 and the second field trial was conducted on November 5, 2002. The first trial included six cultivars of alfalfa: Frisco, Maxi Crop, CUF 101 AUS, CUF 101 USA, Siriver and Mellisa. The seeds were sown using John Deer drilling machine at a rate of 28 – 30 kg/Ha. and the depth of sowing 2-3 cm. followed by 3-4 rounds of irrigation to initiate seeds germination and emergence, each of 6 mm/day. Each cultivar was arranged in a strip length of 165 meters with a width of 24 meters extending from the beginning of the third tower to the end of the fifth tower of the pivot with an area of 3,960 M² for each cultivar with a total trial area of 2,376 ha. Estimation of plant density/M² was carried out by calculating the mean of four 0.5 M² random locations in each of the trial towers of each cultivar, then the general average of the three towers. Also, the percentage of virus infection was estimated for each cultivar on each occasion (in a

similar method of plant density estimation), depending on the number of infected plants, attributed to the total number of plants multiplied by 100.

The second field trial included six cultivars of alfalfa sown using John Deere drilling machine. The trial was arranged into a completely randomized design (CRD), each cultivar was arranged into three replicated strips, each strip with a length of 165 meters extending from the beginning of tower 3 to the end of the tower 5 of the pivot and the width was 4 meters with an area of 660 M²/strip and 1800 M² for each cultivar, so the total area of the trial was 1,8118 ha. Another 13 alfalfa cultivars were sown at the edge of this trial mainly at tower 5, each in a limited strips area for further observation purposes, see Figure 4.

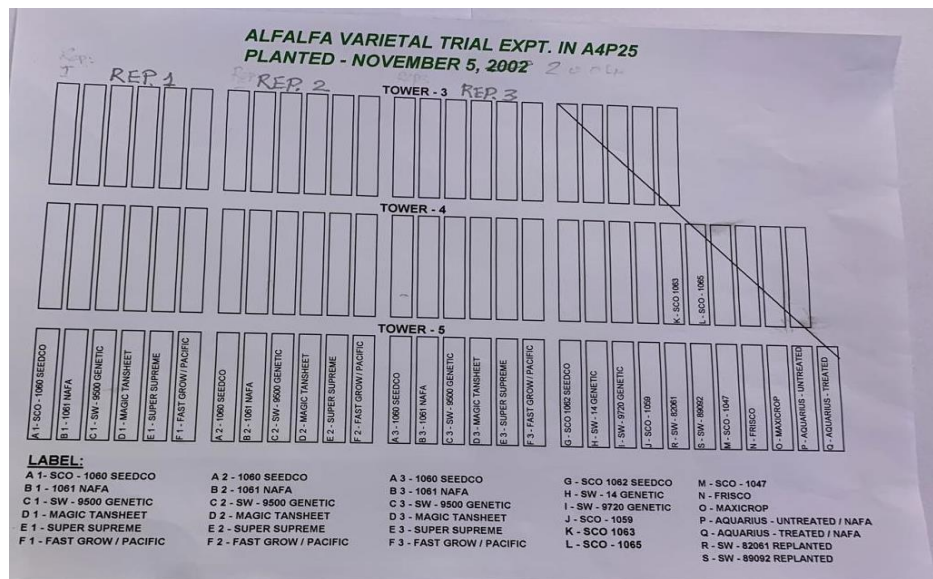


Figure 4: Layout of the different alfalfa hay cultivars in the replicated trial and non-replicated trial at A04P25 pivot.

Estimation of infected plants was carried out by calculating the mean number of plants/M² in four random locations in each of the replicated trial towers of each cultivar, and then we calculate the mean number of plants/ M² in the three towers. In the non-replicated trial, the mean number of plants/ M² of four random locations in the area of each cultivar were recorded. The percentage of virus infection was estimated for each cultivar, depending on the number of infected plants, attributed to the total number of plants multiplied by 100.

Research personnel were directed to monitor each trial regularly and collect data on number of plants/ M², number of infected plants with each type of virus/ M², arrange with the operation department for alfalfa cutting, raking, baling and record the number of balls of each cultivar at each cut. Yield of each cultivar of each cut was calculated into weight units as each ball is around 50 kg and then converted to M.T. /Ha. as per the area of each cultivar, and enter the data of each harvest in the research computer. Frequently tops plants samples were collected one week before cutting and sent to the lab for analysis to monitor nutrition status of the crop, also hay samples were collected to monitor the quality of produced hay.

The source of alfalfa seeds was from the commercial seeds companies in Saudi Arabia as follows: NAFA Co. for SEEDCO (Aus.): cultivars SCO 1060, 1061, 1062, 1063, 1059, 1063, 1065, 1047. and Aquarius. Tansheet Co. for Genetics Seeds: Magic – SW 9500, SW – 14, SW – 9720, SW – 82061, SW 89092. Al Asmida Co for Pacific Seeds, cultivar Fast Grow, ICS Kanahill for Mellisa cultivar and other companies provided the seeds of Super Supreme, Frisco, Maxicrop cultivars.

- *Crop Maintenance*: Daily activities for crop maintenance was carried out by research personnel and involved irrigation of 9 – 12 mm / day during the hottest period of the weeks and in winter months irrigation was scheduled for one day on and one day off; intervals were dependent on the soil moisture. Injection of soluble fertilizers as per the crop needs, Broadleaves weeds and grasses infestations were controlled at the 2-3 trifoliolate leaves stage by spraying mixture of herbicides Broadstrike 40 gram + Super Gallent 0.4 liter + Codacide surfactant 1 L./Ha. followed at 35 days after sowing another spray of Super Gallent 1.5 L+ Dimetoate 1 L + Agral surfactant 0.1 L./Ha. Humic Acid Actosol was injected in summer months with irrigation water at the rate of 5 L./Ha mixed with soluble fertilizers as per crop needs.

3.0 RESULTS AND DISCUSSION

Observation on the first field trial (1999 - 2002 Seasons):

a- Plants density: The plants density in the trial was estimated after three months of sowing of more than 500 plants per square meter. Once the virus infection was observed in the second season on July 18, 2001, the plants density was determined one week after resume irrigation after baling on four sampling occasions: July, August, October and November of the second season 2001, as

well as after the sixth cut of the third season 2002 before the end of the trial as shown in [Table 1] and [Figure 5].

Table 1. Mean number of alfalfa plants / M² of six alfalfa hay cultivars at five sampling occasions in the second and third cropping seasons.

| Cultivar | Mean Number of Plants at different dates / M ² | | | | | % Plants Left vs July 2001 |
|---------------------|---|---------------|-------------|--------------|--------------|-------------------------------|
| | 18/7/2001 | 31/8/2001 | 4/10/2001 | 3/11/2001 | 6/7/2002 | |
| Frisco | 199 | 130 | 67 | 46 | 36 | 18.1 |
| Maxicrop | 191 | 107 | 59 | 40 | 33 | 17.3 |
| CUF 101 Aus. | 184 | 106 | 58 | 37 | 32 | 17.4 |
| CUF 101 USA | 198 | 109 | 78 | 40 | 30 | 15.2 |
| Siriver | 198 | 100 | 52 | 37 | 26 | 13.1 |
| Mellisa | 188 | 106 | 55 | 39 | 27 | 14.4 |
| Mean | 193 | 109.67 | 61.5 | 39.38 | 30.67 | 15.89 |

It was observed, after the appearance of the diseases symptoms, that the mean number of plant density was 193 plants / M², which was equivalent to 38.6% of the original number of plants as a result of: competition between high density plants at the beginning of the first 2001 season, effect of winter frost, and the damage caused by harvest equipment in summer. Plants density continued to decrease leading to a significant reduction in productivity at the second half of the third 2002 season on all cultivars.

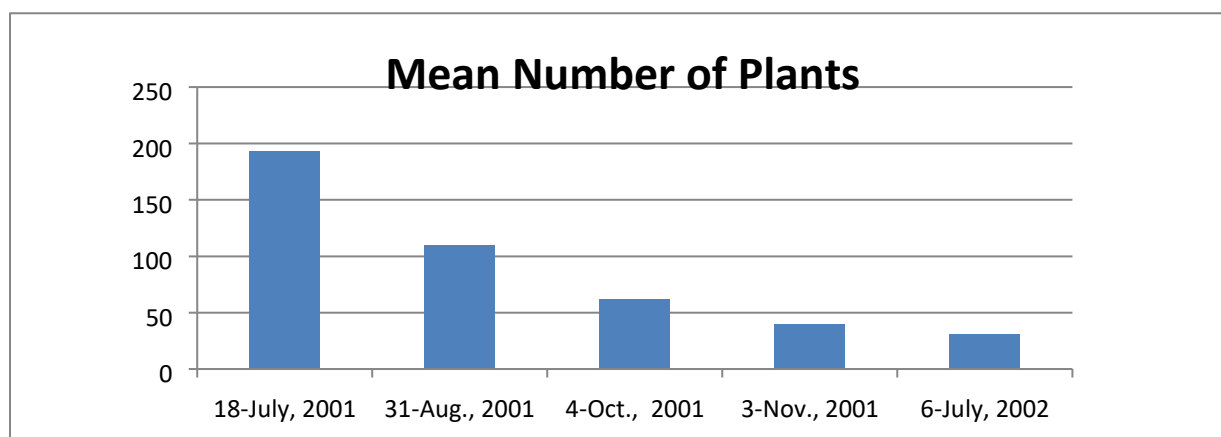


Figure 5. Mean number of alfalfa plants/M² of six alfalfa hay cultivars at five sampling occasions in the second and third cropping seasons.

It was also noticed on November 3, 2001 before the end of the second season that the average plant density was about 39.4 plants / M², which is equivalent to about 28.5% of the plant density of July

2001 when we observed the virus symptoms, and it was equivalent to 7.9% of the plant density after three months of sowing. In the Frisco cultivar, it was observed that the plant density in the second year decreased from 199 plants / M² in July 2001 to 46 plants / M² in November 2001, and in the Maxi Crop cultivar the plant density decreased from 191 plants / M² to 40 plants / M² for the same period and so on the same level of decrease in the rest of the cultivars; the number of plants / M² before the end of the second year ranged from 37 - 46 plants for the different cultivars, where the highest was Fresco followed by Maxi Crop and CUF 101 Americans then Melissa then Siriver and CUF 101 Australian with an average of 37 plants / M². The plant density was estimated on July 6, 2002, before cut # 5 of the third year, which ranged between 26 - 36 plants / M² for the different cultivars, the highest density was the cultivar Fresco, followed by Maxi Crop, then the rest of the cultivars, and the Siriver was the lowest density with an average of 26 plants / M². *b- Rate of virus infection:* the number of infected plants was estimated for each type of virus disease / M² on the different cultivars in the second half of the second season on four occasions: August 9, October 4, October 17, November 3, 2001 and also in the third season on July 6, 2002 before the end of the trial. The results are shown in [Table 2] and [Figure 6].

Table 2. Number of infected plants and the percentage of infection with each disease on six alfalfa hay cultivars in the second and third cropping seasons.

| Date of Sampling | Name of the Disease | Number of Infected Plants and % Virus Infection | | | | | | Mean |
|------------------|---------------------|---|-----------|-------------|-------------|---------|-----------|----------|
| | | Frisco | Maxi Crop | CUF 101 AUS | CUF 101 USA | Siriver | Mellisa | |
| 9 Aug. 2001 | Enation Virus | 3.8 | 3.58 | 6.75 | 2.92 | 3.25 | 3.25 | 3.93 |
| | Leaves Mosaic | 0.08 | 0.42 | 1.25 | 0.58 | 0.08 | 0.125 2.5 | 0.42 |
| | Witches Broom | 1.08 | 3.63 | 2.25 | 2.83 | 3.5 | 105.5 | 2.67 |
| | Mean plants # | 129.6 | 106.6 | 106.3 | 109.3 | 100.2 | | 109.58 |
| | % Infection | 3.71 | 7.33 | | 5.79 | 6.81 | 5.57 | 6.55 |
| 4 Oct. 2001 | Enation Virus | 14.6 | 14.0 | 10.11 15.6 | 16.8 | 13.0 | 7.6 | 13.6 |
| | Leaves Mosaic | 0.00 12.3 | 0.00 | 0.33 9.0 | 0.3 | 0.00 | 0.33 11.6 | 0.16 |
| | Witches Broom | 67.3 | 12.6 | 58.0 | 9.6 | 12.96 | 54.6 | 11.34 |
| | Mean plants # | | 59 | | 78 | 52.3 | | 61.03 |
| | % Infection | 41.45 | 45.07 | 42.98 | 34.23 46.18 | 12.0 | 10.3 | 49.7 |
| 17 Oct. 2001 | Enation Virus | 10.6 0.33 | 9.0 | 36.96 | 10.8 | 0.00 | 0.00 | 14.3 8.6 |
| | Leaves Mosaic | 8.26 | 0.3 | 0.33 | 0.00 0.16 | 8.0 | 7.96 | |
| | Witches Broom | 61.3 | 6.9 | 9.33 | 7.9 8.06 | 43.6 | 46 | |
| | Mean plants # | | 46.3 | 44.6 | 47 48.13 | 45.87 | 57.08 | |
| | % Infection | 31.37 | 35.27 | 53.72 43.01 | 35.31 | 9.0 | 7.0 | 11.0 6.3 |
| 3 Nov. 2001 | Enation Virus | 9.3 | 6.6 | 8.20 | | 0.32 | 0.66 | |
| | Leaves Mosaic | 0.00 4.0 | 0.00 | 0.00 | 0.00 0.16 | 2.33 | 2.66 | |
| | Witches Broom | 46.3 | 3.63 | 2.6 | 2.0 2.87 | 36.6 | 39.0 | |
| | Mean plants # | | 40.0 | 36.6 | 39.6 39.68 | 30.95 | 24.76 | 28.06 |
| | % Infection | 26.72 | 25.65 | 37.31 | 20.96 | | | 11.47 |
| 6 July 2002 | Enation Virus | | | 15.0 | 8.17 | 12.5 | 9.33 | |
| | Leaves Mosaic | 0.66 5.5 | 1.3 | 1.6 | 1.5 | 1.33 | 1.83 | 1.37 |
| | Witches Broom | 35.6 | 8.8 | 10.0 | 7.17 | 12.33 | 7.83 | 8.61 |
| | Mean plants # | | 32.5 | 32.33 | 29.67 | 26.33 | 27.33 | 30.63 |
| | % Infection | 51.58 | 55.46 | 82.55 | 56.82 | 86.27 | 69.4 | 68.89 |

It was noticed that the average rate of virus infection on the different cultivars was low in the second season and it was equivalent to 6.55% on August 9, 2001 twelve days after cut # 6, but it rose to 46.18% in October 4, 2001 after 12 days from cut # 8 of the second season (2001). Bear in mind that the plants were infested with aphids in the second season in March 2001 after cut # 1 and in May 2001 after cut # 3 and in July after cut # 5 where Dimethoate insecticide was sprayed on those occasions to control the aphids' infestations. It was noted with the passage of time that

the percentage of infected plants decreased to 43.01% in October 17 and to 28.62% in November 3, 2001 due to the death of infected plants; and in the third year, by the end of the trial in July 2002, the percentage of infected plants increased to 68.89%.

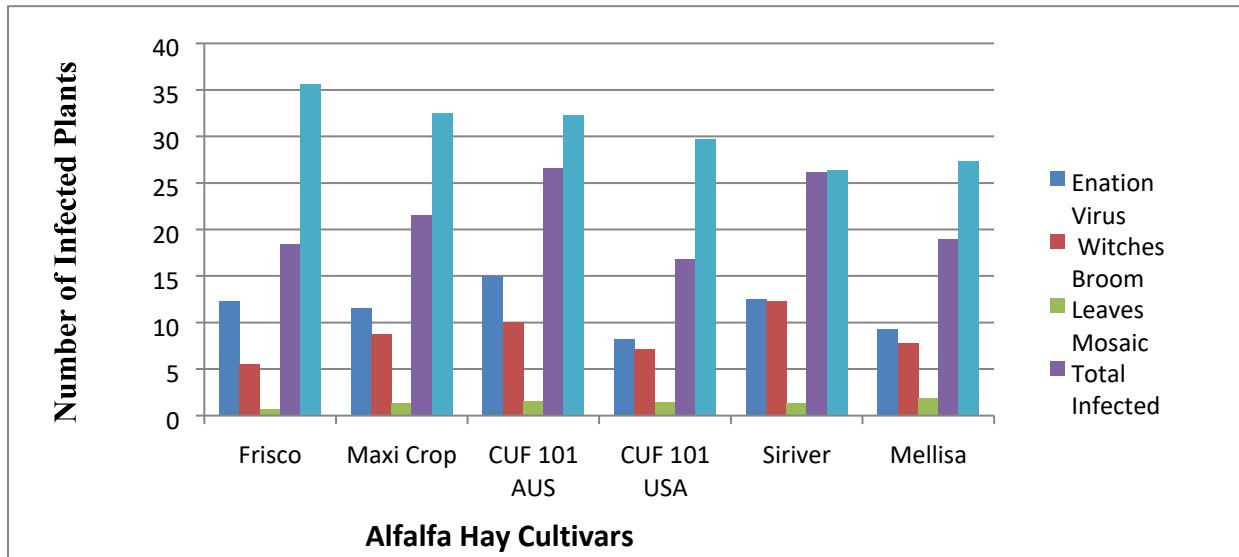


Figure 6. Number of infected plants with the diseases on six cultivars of alfalfa by the end of the trial on July 6, 2002 in the third season.

It was also observed by the end of the third season on July 2002 that the cultivars Siriver and CUF 101 Australian were the highest infected with the diseases, and the cultivar CUF 101 American was the lowest infected, see [Figure 6]; the cultivar Fresco showed less infection in the third season. In the first survey in August 2001, the percentage of disease infection on the two cultivars, Frisco and CUF 101 American ranged between 3.7 - 5.8% and it rose in the last survey to 51.2 - 56.8% on July 6, 2002. Also, by the end of the trial, the Maxi-Crop, CUF 101 American and Melissa cultivars were more infected with the diseases than Frisco. Most of the economic damage to alfalfa plants of the various cultivars was attributed to the alfalfa enation virus disease and the alfalfa witches' broom disease and this agrees with the findings of Cook and Wilton [1984], but the infection with the alfalfa mosaic virus disease (Calico) was low or nil. *c- Alfalfa hay Productivity and its Relationship with Crop Age and Virus Infection:* Alfalfa hay productivity was estimated in the different cuts for three seasons: 2000, 2001, and 2002 are shown in Table 3 and Figure 7.

Table 3. Effect of virus infection on alfalfa hay productivity M.T / Ha. in three agricultural seasons for the period 2000-2002.

| Harvest # | 2000 Season | | 2001 Season | | 2002 Season | |
|----------------------|-------------|--------------|-------------|--------------|-------------|--------------|
| | Date | Quantity | Date | Quantity | Date | Quantity |
| Cut # 1 | 8/4 | 4.65 | 7/3 | 4.67 | 16/3 | 3.67 |
| Cut # 2 | 18/5 | 4.85 | 10/4 | 4.16 | 23/4 | 3.22 |
| Cut # 3 | 19/6 | 4.78 | 10/5 | 3.32 | 20/5 | 1.75 |
| Cut # 4 | 13/7 | 4.27 | 5/6 | 3.25 | 13/6 | 1.92 |
| Cut # 5 | 12/8 | 3.86 | 28/6 | 2.87* | 8/7 | 1.90 |
| Cut # 6 | 10/9 | 4.06 | 28/7 | 3.41 | 8/8 | 1.25** |
| Cut # 7 | 14/10 | 4.07 | 27/8 | 2.69 | - | - |
| Cut # 8 | 2/12 | 2.37 | 23/9 | 2.28 | - | - |
| Cut # 9 | - | - | 4/11 | 2.51 | - | - |
| Cut # 10 | - | - | 25/12 | 1.61 | - | - |
| Total M.T/Ha. | | 32.94 | | 30.77 | | 13.71 |

*** Virus disease symptoms appeared on the plants * * Termination of the trial after cut # 5 of the third season**

The total yield of alfalfa hay obtained in the first season 2000 was 32.94 M.T / Ha., and hay productivity decreased to 30.77 M.T / Ha. in the second season 2001 which was 6.6% less than the first season; productivity in the third season decreased to 13.71 M.T / Ha. and this was 58.38% less than the first season. In the second season 2001, it was noticed that the productivity decreased significantly after the third cut with a yield of 3.25 M.T / Ha. and this was less than the second cut with 4.16 M.T / Ha. due to the onset of virus infection. To compensate for this yield reduction, we adapted a fertilization program that meets the needs of the plants while adding Humic Acid (Actosol) with fertilizers injection through irrigation water at a rate of 5 L / Ha. after each cut to overcome plants stress. This resulted in a slight yield increase to 3.41 M.T / Ha. of cut # 6, but productivity decreased in the cuts # 7, 8 and cut # 9 with a yield of 2.69, 2.28, and 2.51 M.T / Ha. respectively. As the weather temperature dropped in November and December of the second season 2001, productivity of cut # 10 decreased to 1.61 M.T / Ha.

In the third season (2002), the remaining plants compensated for the lack of their density with branching and good growth by the end of winter waiting period, and the productivity of the first and second cuts increased to 3.67, 3.22 M.T / Ha. respectively, but after that productivity resumed to decrease continuously due to the stress caused on the virus infected plants with the rise of the

weather temperature and also after spraying herbicide mixture of Stomp and Pursuit to control weeds infestations, and the yield was 1.75, 1.92, 1.90 and 1.25 M.T / Ha for the cut # 3, 4, 5 and cut # 6 respectively. Comparing productivity in the third season until August 8, 2002 with the productivity in the second season for the same period until July 28, 2001: it was noted that productivity in third season decreased from 21.68 to 13.71 which was 36.8% less than the second season, although the productivity period in the third season was eleven days longer, see Figure 7.

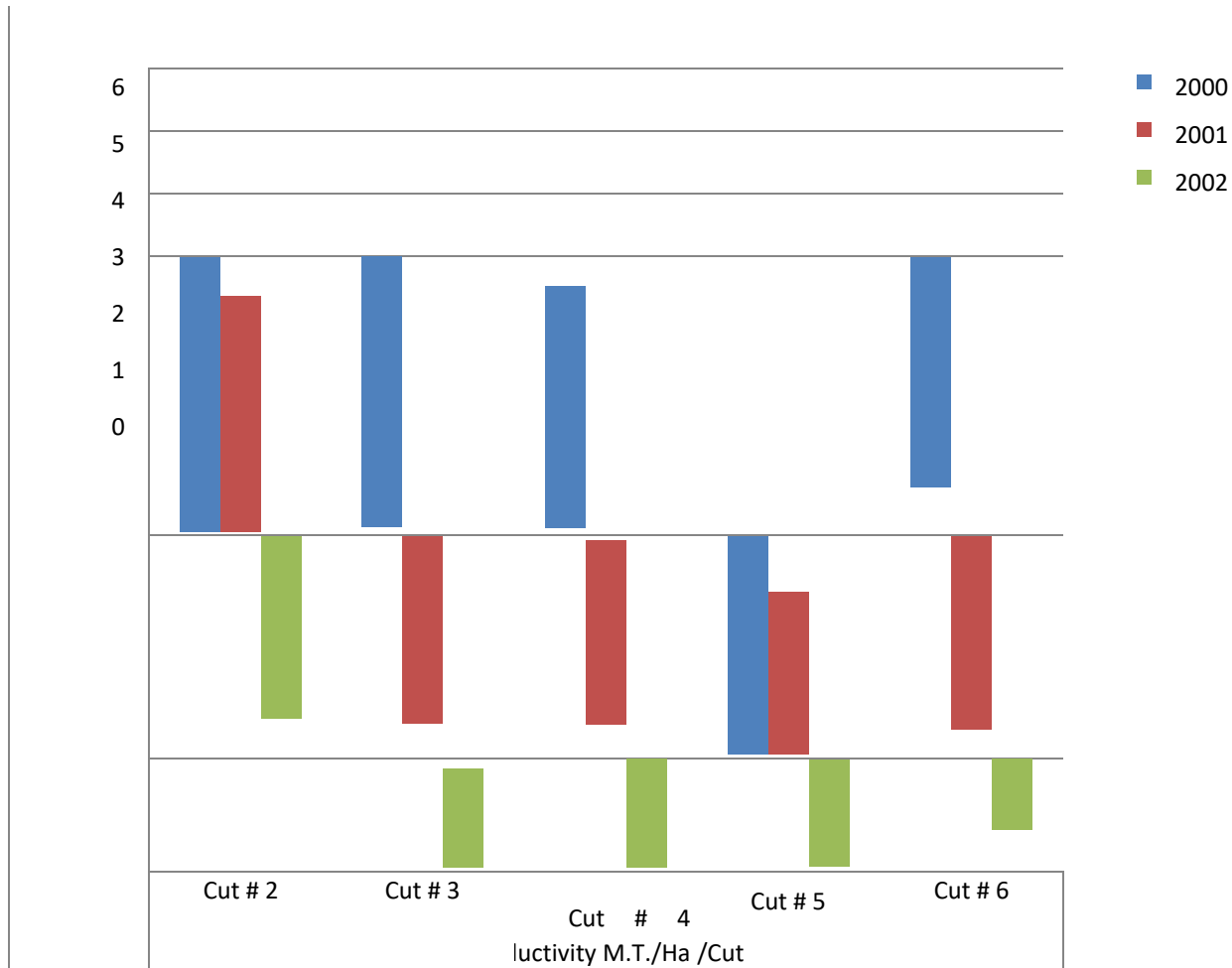


Figure 7. Productivity of alfalfa hay cultivars M.T./Ha. in relationship with Crop Age and Virus Infection in the three cropping seasons.

d- Comparison of the productivity of the different cultivars under the conditions of virus infection: The productivity of the different alfalfa hay cultivars was compared under the conditions of virus infection starting from cut # 5 in the second growing season in July 2001 when the symptoms of virus infection appeared on the plants and it is shown in [Table 4] and [Figure 8]. The productivity

expressed M.T / Ha was adopted as an indicator for the degree of susceptibility of any cultivar to virus infection as the infection with the virus disease was correlated with a decrease in the plant's density and decreased growth vigor.

Table 4. Comparison of the hay productivity of the different alfalfa cultivars under the conditions of virus infection in the second and third cropping seasons.

| Cut # | Hay Productivity of Alfalfa Cultivars | | | | | | Mean Yield M.T / Ha. |
|-----------------|---------------------------------------|--------------|-------------------|----------------|---------|---------|-------------------------|
| | Frisco | Maxi Crop | CUF 101 AUS | CUF 101 USA | Siriver | Mellisa | |
| Cut # 5 | 2.57 | 2.73 | 2.21 | 3.38 | 3.48 | 2.83 | 2.87 |
| Cut # 6 | 3.20 | 3.39 | 2.31 | 4.12 | 4.5 | 2.95 | 3.41 |
| Cut #7 | 2.71 | 2.12 | 1.91 | 3.38 | 3.37 | 2.63 | 2.69 |
| Cut # 8 | 2.14 | 2.27 | 1.62 | 2.79 | 2.61 | 2.23 | 2.28 |
| Cut # 9 | 2.14 | 2.42 | 2.65 | 2.94 | 2.61 | 2.23 | 2.5 |
| Cut # 10 | 1.71 | 1.82 | 1.03 | 1.62 | 1.85 | 1.62 | 1.61 |
| Cut # 1 | 3.42 | 3.64 | 3.38 | 3.82 | 3.91 | 3.85 | 3.67 |
| Cut # 2 | 3.14 | 3.18 | 2.65 | 3.24 | 3.48 | 3.64 | 3.23 |
| Cut # 3 | 1.71 | 1.47 | 1.47 | 1.76 | 1.85 | 2.02 | 1.75 |
| Cut # 4 | 1.86 | 1.97 | 1.47 | 2.35 | 1.85 | 2.02 | 1.92 |
| Cut # 5 | 1.86 | 1.82 | 1.62 | 2.35 | 1.74 | 2.02 | 1.90 |
| Cut # 6 | 1.86 | 1.06 | 0.74 | 1.91 | 0.87 | 1.01 | 1.24 |
| Total | 28.32 | 28.09 | 23.06 | 33.66 | 32.12 | 29.05 | 2.42 |

It was noticed that hay productivity of the cultivar CUF 101 American, outperforming all cultivars, with a total productivity of 33.66 M.T / Ha for twelve cuts, followed by a Siriver with a production of 32.12 M.T / Ha, followed by Melissa 29.05 M.T / Ha, then Maxi Crop, then Frisco, and finally CUF 101 Australian with a low production of 23.06 M.T / Ha, According to field observations, the productivity of the cultivar CUF 101 American significantly outperformed the Siriver in the company's fields under the conditions of the Integrated Pest Management Program (Natwick, 2004), and it appears that the difference in hay productivity between these two cultivars in this trial was limited due to the protection from virus injury by early spraying of the trial with Dimethoate to control aphids infestations, which delayed the infection of the plants; also the application of fertigation program according to the results of tissue analysis which enhanced plants growth and compensated for the damage caused by the diseases infection.

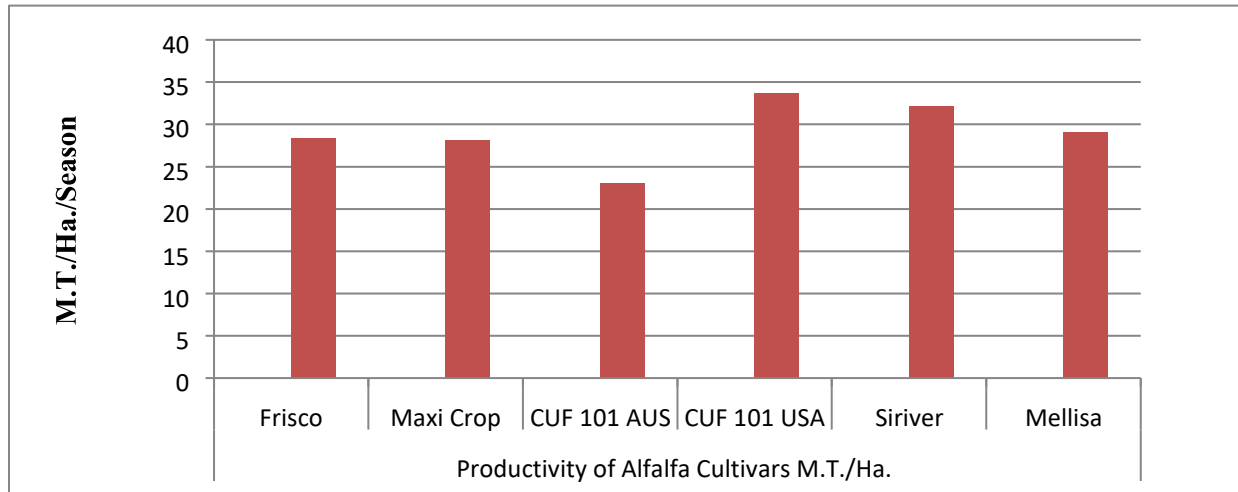


Figure 8. Comparison of alfalfa hay yield of the different alfalfa cultivars M.T./Ha. under the conditions of virus infection in the second and third cropping seasons 2001 and 2002.

These results indicate that all alfalfa cultivars were subject to infection with the diseases, but they varied, and the next step is to search for cultivars of low disease susceptibility with high quality. The cultivars must be characterized by acceptable level of resistance to cowpea aphid *Aphis cracivora*, which does not allow them to form high numbers, and also it has a degree of resistance to the leaf hopper (Jassid) *Empoasca faba*, The provision of these traits in any cultivar could lead to obtain high hay productivity under the Integrated Pest Management program in the company fields (Natwick, 2004). Results also indicate the possibility of increasing productivity when we provide the crop's needs of nutrients. In addition, weeds control through following appropriate date for sowing before the onset of low temperatures in the fall to avoid the early infestation with summer weeds which were hard to control such as purslane, fleabane. This shall lead to the establishment of a good crop stand before the germination of winter weeds such as ryegrass, sow thistle, shepherds' purse etc.

Observations on the second field trial (2003 – 2004):

a- Comparison of the alfalfa hay productivity in the replicated trial in two seasons

(2003 & 2004): The alfalfa hay productivity of the different alfalfa cultivars in the replicated trial are shown in [Table 6] and [Figure 9].

Table 6. Comparison of the alfalfa hay productivity of the different cultivars in the replicated trial M.T / Ha. in two agricultural seasons 2003 and 2004.

| Season | Alfalfa hay productivity of different cultivars M.T / Ha | | | | | |
|--------|--|------------|---------|---------------|---------------|-----------|
| | SCO - 1060 | SCO - 1061 | SW 9500 | Magic SW 9301 | Super Supreme | Fast Grow |
| 2003 | 28.8 | 30.31 | 33.35 | 32.83 | 32.33 | 33.85 |
| 2004 | 24.51 | 25.52 | 25.01 | 27.02 | 26.02 | 26.53 |
| Total | 53.31 | 55.83 | 58.36 | 59.85 | 58.35 | 60.38 |

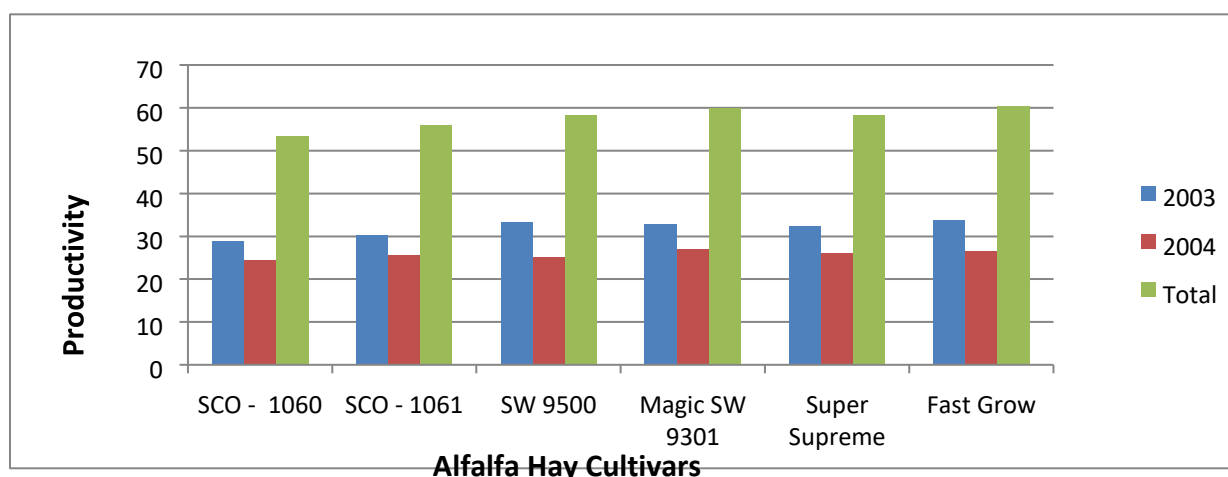


Figure 9. Comparison of the productivity of the alfalfa hay cultivars in the replicated trial in 2003 and 2004 seasons.

Alfalfa hay productivity of the different cultivars in the first 2003 season was higher than the second 2004 season due to high plants density in the first season compared to second season and the freedom of the plants from virus infection. In 2003 season, Fast Grow cultivar produced 33.8 M.T./Ha. and this was higher than other cultivars followed by SW 9500 with 33.35 M.T./Ha. then Magic and Super Supreme with 32.83, 32.33 M.T./Ha. respectively. and SCO 1061 with 30.31 M.T./Ha; SCO 1060 was the lowest with 28.8 M.T./Ha.

In 2004 season, Magic cultivar produced high hay yield with 27.02 M.T./Ha. followed by Fast Grow and Super Supreme cultivars with 26.53, 26.02 M.T./Ha. respectively then SCO 1061 and SW 9500 cultivars with 25.52, 25.01 M.T./Ha. respectively, while SCO 1060 was the lowest with 24.51 M.T./Ha. The total hay yield of the different alfalfa cultivars over the two seasons 2003 and 2004 shown that Fast Grow was the highest with 60.38 M.T./Ha. followed by magic with 59.85

M.T./Ha. then SW 9500 and Super Supreme each with 58.35 M.T./Ha. then SCO with 55.85 M.T./Ha. then SCO 1060 with 53.31 M.T./Ha. *b- Rate of disease infection:* the number of infected plants with the diseases was estimated for each type of disease / M² on the 19 alfalfa hay cultivars in the second half of the second season on October 6, 2004. The results are shown in [Table 7] and [Figure 10].

Table 7. Number of infected plants and the percentage of infection with the diseases on the 19 alfalfa cultivars in the second half of the second growing season (2004).

| Cultivar | Mean Density/ M ² | Number of Infected Plants and % Virus Infection | | | | | |
|--------------------|---------------------------------|---|------------|----------------|------------|----------------------|------------|
| | | Alfalfa Enation Virus | %Infection | Witches' Broom | %Infection | Alfalfa Mosaic Virus | %Infection |
| 1) SCO 1060 | 55 | 24 | 43.60% | 5 | 9.05% | 0 | 0.00% |
| 2) SCO 1061 | 48 | 21 | 43.75% | 5 | 10.42% | 0.33 | 0.69% |
| 3) SW 9500 | 48 | 22 | 45.80% | 4 | 8.30% | 0.33 | 0.68% |
| 4) Magic - SW 930 | 57 | 26 | 45.60% | 5 | 8.77% | 0.33 | 0.57% |
| 5) Super Supreme | 47 | 18 | 38.29% | 4 | 8.50% | 0.33 | 0.70% |
| 6) Fast Grow | 47 | 21 | 44.68% | 4 | 8.50% | 0.33 | 0.70% |
| 7) SCO 1062 | 57 | 24 | 42.10% | 5 | 8.77% | 1 | 1.75% |
| 8) SW 14 | 46 | 23 | 50.00% | 3 | 6.50% | 1 | 2.20% |
| 9) SW 9720 | 48 | 23 | 47.90% | 5 | 10.42% | 0 | 0.00% |
| 10) SCO 1059 | 45 | 25 | 55.50% | 3 | 6.60% | 0 | 0.00% |
| 11) SCO 1063 | 47 | 22 | 46.80% | 6 | 12.76% | 1 | 2.10% |
| 12) SCO 1065 | 40 | 26 | 65.00% | 3 | 7.50% | 0 | 0.00% |
| 13) SCO 1047 | 38 | 23 | 60.50% | 3 | 7.89% | 0 | 0.00% |
| 14) Frisco | 40 | 17 | 42.50% | 2 | 5.00% | 1 | 2.50% |
| 15) Maxicrop | 38 | 19 | 50.00% | 4 | 10.50% | 0 | 0.00% |
| 16) Aquarius (TS) | 46 | 24 | 52.00% | 3 | 6.50% | 0 | 0.00% |
| 17) Aquarius (UTS) | 34 | 17 | 50.00% | 1 | 2.90% | 0 | 0.00% |
| 18) SW 87061 | 44 | 17 | 38.60% | 0 | 0.00% | 0 | 0.00% |
| 19) SW 89092 | 36 | 16 | 44.40% | 2 | 5.50% | 0 | 0.00% |

It was shown on all of the tested cultivars high infestation with alfalfa enation virus with a range from 38.29 – 65.00% followed by Witches' Broom mycoplasma disease with infection rate ranged

2.90 to 12.76% except cultivar SW 87061 with zero infection. Infection rate with alfalfa mosaic virus was very low on all cultivars and ranged from zero to 2.5%; 10 cultivars out of 19 were with zero infection. The infection rate with the alfalfa enation virus in the replicated trial (Cultivars # 1 to 6) ranged 38.29 to 45.80%; Super Supreme cultivar was with 38.29% which was less than other cultivars, while other cultivars were with infection rate 43.75 to 45.6%. The infection rate with the alfalfa enation virus in the non-replicated trial (Cultivars # 7 to 19) was high on most of the cultivars and ranged 42.10 to 60.50% except SW 87061 was with 38.60% infection which was less than other cultivars. The infection rate with witches’ broom disease in the replicated trial (Cultivars # 1 to 6) ranged 8.3% to 10.42%, and the infection rate with this disease in the nonreplicated trial (Cultivars # 7 to 19) ranged 2.90 to 10.50% except SW 87061 was with zero infection

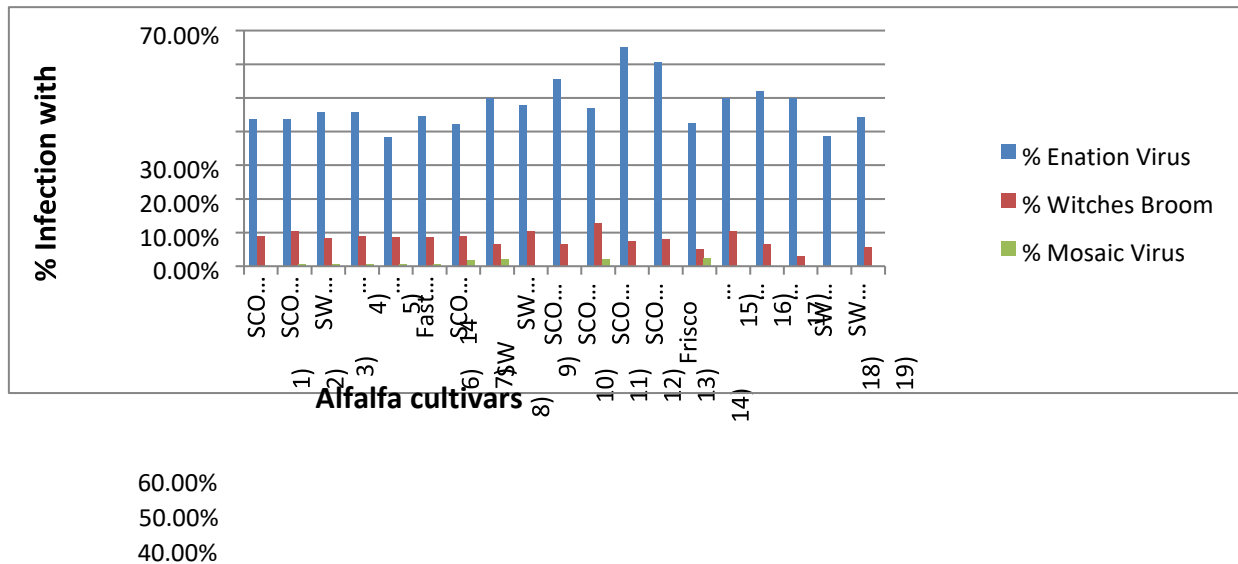


Figure 10. The percentage of infection with the diseases on 19 cultivars of alfalfa in the second half of the growing season (2004).

4.0 CONCLUSION

1- All of the tested alfalfa cultivars were susceptible to infection with alfalfa enation virus which is biologically transmitted by cowpea aphid *Aphis cracivora*, and all of these cultivars were susceptible to infection by witches’ broom disease caused by mycoplasma which is transmitted biologically by the leaf hopper (Jassid) *Empoasca faba*; the infection with alfalfa mosaic virus (Calico) was low. Most of the economic damage on the different cultivars was caused by the alfalfa

enation virus disease followed by the witches' broom disease, and these results were in agreement with the findings of (Cook & Wilton, 1984).

2- Infection of alfalfa crop with these diseases lead to a severe reduction on the cultivars productivity due to decreased plants density and plants growth as a result of stress on the plants, depleting plant growth with continuous harvest cuttings over the life span of the crop and the damage caused on the plants by harvesting equipment which lead to the loss of plants density after exposure to frost in winter and hot in summer. Reduction of plant density lead to high infestation with winter weeds and grasses such as shepherd's purse, sow thistle, rye grass, love grass etc.; and summer weeds and grasses such as purslane, fleabane and sprangle top etc. These weeds and grasses significantly affected the hay yield and quality.

3- It was possible to delay infection with the alfalfa enation virus and witches' broom diseases by early control of vector insects which transmit these diseases, as well as improving the tolerance of plants through the improvement of good crop stand by sowing the seeds before the onset of low temperatures in the fall (October/ November) and through the appropriate timing of weed control, care in irrigation and fertilization application to strengthen the plants to stand the exposure to the environmental stress.

4- Under the conditions of these trials, and in reference to plant nutrition care and control of aphids, and as per the cultivars productivity in the trials, the alfalfa cultivar CUF 101 was less susceptible to the virus diseases followed by Siriver; but according to the field observations, the productivity of the cultivar CUF 101 was significantly superior to the Siriver in the company's fields under the conditions of Integrated Pest Management program (Natwick, 2004)

5- The percentage loss in alfalfa hay yield due to diseases infection was estimated at 17.6% in the second season 2001 and about 36.8% in the third season 2002 of cultivation compared to productivity without virus infection in the first season 2000 until the mid of the second season.

6- Productivity of alfalfa hay cultivars CUF 101 and Siriver reached above 30 M.T./Ha under aphid-controlled conditions in the first field trial (1999 – 2002). In the second field trial (2002 – 2004), alfalfa hay productivity of the cultivars Fast Grow, SW 9500, Magic (SW 9301) and Super Supreme reached above 30 M.T./Ha in the first season 2003. In the second season 2004, alfalfa hay productivity of the cultivars Magic, Fast Grow and Super Supreme reached above 26 M.T./Ha.

Productivity over the two seasons 2003 and 2004 shown Fast Grow and Magic were the highest with 60.38, 59.85 M.T./Ha. respectively.

4.1 RECOMMENDATIONS

- 1- Recommend the farmers to grow alfalfa hay cultivar CUF 101 (USA) in large areas as it proved to produce higher yield than Siriver under the IPM program at TADCO farm project.
- 2- Recommend the farmers to grow the alfalfa hay cultivars with productivity above 29 M.T./Ha./season in limited number of pivots areas under IPM program adopting two years crop rotation with cereal crops, then evaluate the net profit by the end of the second season.
- 3- Recommend to sow alfalfa seeds in the fall season to establish strong alfalfa crop stand, and avoid sowing in the summer season to escape early spread of virus diseases, insects and weeds infestations.

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